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TECTONIC GEOMORPHOLOGY OF THE ANDES WITH SIR-A AND SIR-B

Arthur L. Bloom and Eric J. Fielding
Department of Geological Sciences and
Institute for the Study of Continents, Cornell University
Ithaca, New York

Data takes from SIR-A and SIR-B crossed all of the principal geomorphic provinces of the central Andes between 17° and 34°S latitude (Figure 1). In conjunction with TM images and photographs from hand-held cameras as well as from the Large Format Camera that was flown with SIR-B, the radar images give an excellent sampling of Andean geomorphology. In particular, the radar images show new details of volcanic rocks and landforms of late Cenozoic age in the Puna, and the exhumed surfaces of tilted blocks of Precambrian crystalline basement in the Sierras Pampeanas.

SIR-A data take 31 and SIR-B data take 39.6 crossed at about 19°S directly over a volcano 4600 m high in northern Chile (Figure 2). The western wall of the Andes at this latitude is a sheet of volcanic ejecta that drapes down to the west from a line of stratovolcanoes that range from 4500 to 5000 m in height. Volcanic and other sediments fill the tectonic longitudinal valley of northern Chile to a depth of 1000 m or more. The coastal cordillera of uplifted basement rocks forms a tectonic dam about 1 km above sea level, behind which the massive volcaniclastic deposits have been ponded (Bloom, in press).

To the southeast along SIR-B data take 39.6, the Ollague volcanic field on the Chile-Bolivia frontier has andesite stratovolcanoes 12 to 25 million years old that are partly buried by massive ignimbrite sheets. The ignimbrite sheets may be 3 to 5 million years old, and are in turn topped by younger andesite stratovolcanoes. A weathered and possibly wind-eroded fracture pattern in the ignimbrite sheets gives a distinct bright radar signature wherever they appear along the radar tracks (Fielding et al., 1986, esp. Figure 3).

North of 27°S latitude, the eastern flank of the Andes is the Subandean fold and thrust belt, including the Santa Barbara group of deformed sedimentary rocks near Salta, Argentina. The Subandean belt is a region of major petroleum exploration along the entire eastern Andes from Colombia south to Argentina. Ford et al., (1986, p. 24-25) illustrated the geology of the Subandean belt at 5°S latitude on the Peru-Ecuador frontier, farther northwest along SIR-B data take 39.6.

There is no active volcanism in the Andes between 27°S and 33°S. This is the zone of flat-slab subduction where the Pacific Nazca Plate passes under western South America with a dip of less than 10° (Jordan et al., 1983). Here, the Andean orogenic belt narrows abruptly to a width of no more than 200 km. SIR-A data take 29-30 crossed this section of the Andes on a northeastward course at about 30°S latitude, imaging the Cordillera Principal, the Cordillera Frontal, the Precordillera, and several of the Sierras Pampeanas - all of the major tectonic units across the flat-slab zone of the Andes.

The Sierras Pampeanas are of great interest to North American structural geologists because they are modern analogs of the Laramide blocks that created the central Rocky Mountains about 60 million years ago (e.g., Fielding and Jordan, in review). Individual Pampean ranges are blocks of igneous and metamorphic Precambrian and Paleozoic basement rocks, 50-100 km wide, uplifted as much as 6 km along thrust faults. They are separated by arid sedimentary basins in which several km of alluvial sediments have accumulated in late Cenozoic time. The surfaces of the tilted Pampean blocks are intricately fractured by ancient tectonic lineaments, which in part have been reactivated by contemporary uplift (Figure 3). They seem to be part of the ancient Gondwana shield and platform that was disrupted when South America separated from Africa in the Mesozoic Era. They were eroded flat and have either been exposed at the surface or slightly buried under alluvium from late Paleozoic time until their rejuvenation by recent involvement in Andean tectonics. They must be one of the world's most remarkable examples of exhumed topography. Their intricate surface patterns of intersecting fractures have been only slightly modified by modern fluvial erosion. They stand out clearly on Landsat TM, SIR-A, and SIR-B images. One of the more remarkable Pampean Ranges, known as Pie de Palo, and the adjacent Precordillera were photographed in color infrared by the Large Format Camera during STS Mission 41-G, and the photograph has been widely reproduced.

South of 33°S latitude, the Andean Cordillera is lower and dominated by a chain of andesite stratovolcanoes that continue into Tierra de Fuego. South of 42°S latitude, this great volcanic chain was covered by the Patagonian mountain ice cap during Pleistocene ice ages, and still supports small valley glaciers. The Chilean volcano Michinmahuida (2400 m high, 43°S, 73°W) was imaged by four data takes of SIR-B radar, and illustrates the definition achievable by shuttle imaging radar over inaccessible, cloud-covered regions (Elachi et al., 1986, Fig. 7; Fielding et al., 1986, Fig. 6; Ford et al., 1986, p. 74-75).

REFERENCES

Bloom, A. L. (in press), Coastal landforms, in Short, N. M., Editor, Pictoral Atlas of Regional Landforms from Space: NASA Special Publication no. _____, chap. 6.

Elachi, C., Cimino, J. B., and Settle, M., 1986, Overview of the Shuttle Imaging Radar-B preliminary scientific results: Science, v. 232, p. 1511-1516.

Fielding, E. J. and Jordan, T. E. (in review), Active deformation of the boundary between thin- and thick-skinned shortening, Precordillera and Sierras Pampeanas, Argentina, and comparison with ancient Rocky Mountain deformation in North America: submitted for Schmidt, C. J., and Perry, W. J., eds., Interaction of the Rocky Mountain foreland cordilleran thrust belt, Geological Society of America Special Paper _____.

Fielding, E. J., Knox, W. J., Jr., and Bloom, A. L., 1986, SIR-B radar imagery of volcanic deposits in the Andes: IEEE Transactions on Geoscience and Remote Sensing, v. GE-24, p. 582-589.

Ford, J. P., Cimino, J. B., Holt, B., and Ruzek, M. R., 1986, Shuttle imaging radar views the Earth from Challenger: The SIR-B experiment: JPL Publication 86-10, 135 p.

Jordan, T. E., Isacks, B. L., Allmendinger, R. W., Brewer, J. A., Ramos, V. A., and Ando, C. J., 1983, Andean tectonics related to geometry of subducted Nazca plate: Geological Society of America Bulletin, v. 94, p. 341-361.

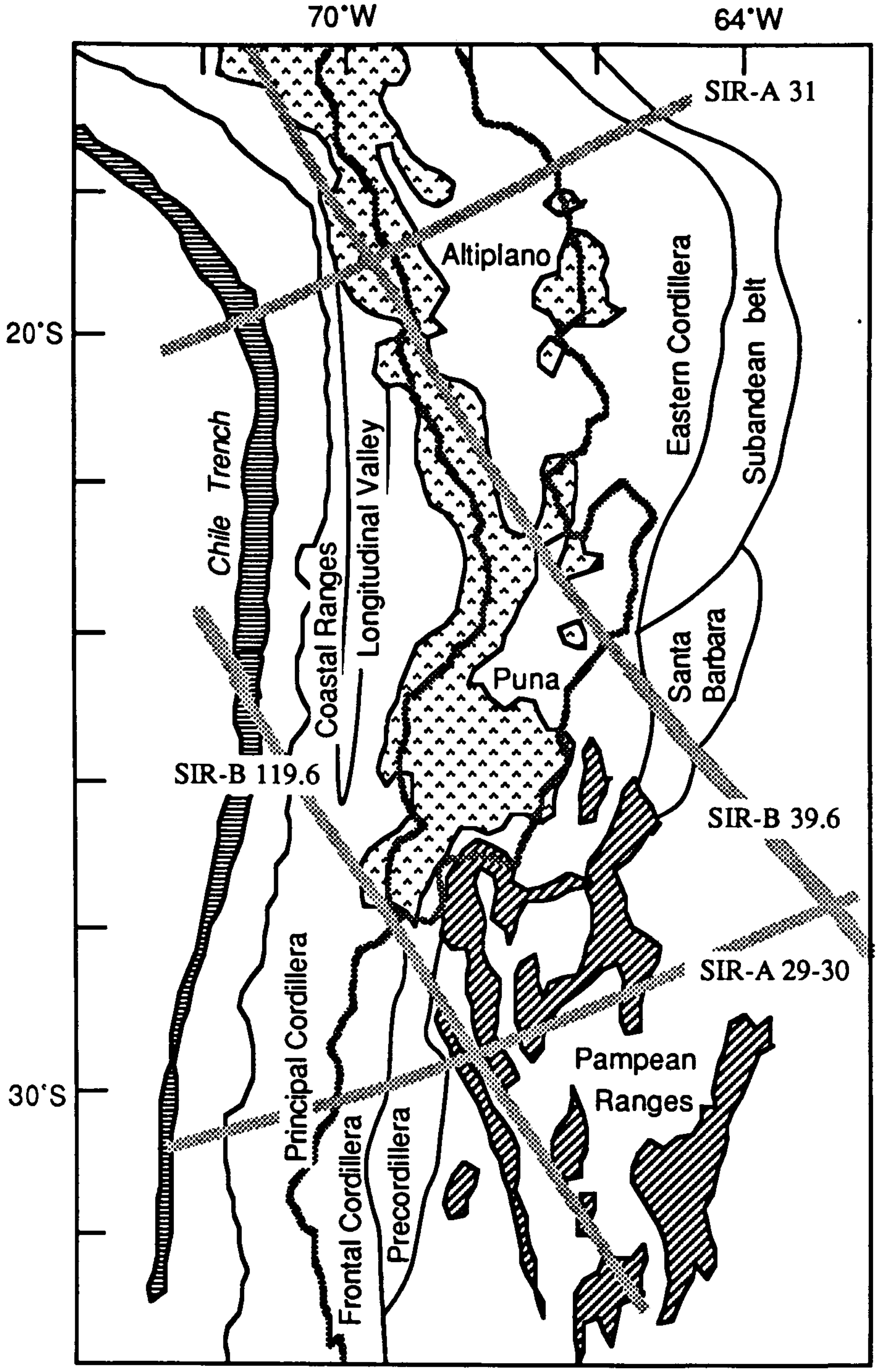

Figure 1. The major geomorphic units of the central Andes with SIR-A and SIR-B ground tracks superimposed. Other SIR-B tracks crossed the southern Andes between 40° and 45° S. Drainage divides (dark grey lines) enclose the Altiplano and Puna regions; late Cenozoic volcanoes shown in triangular pattern; Sierras Pampeanas shown in diagonal shading (modified from Jordan, et al., 1983, Fig. 4).

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Figure 2. Stratovolcano at 19°S, 69°25'W in northern Chile. Coastal cliffs are almost 1 km high. This negative copy of SIR-A optical data take 31 makes the ocean appear in light shades, but gives the shadow effects of lighting from the upper right. Scale dots at bottom are spaced at about 7 km.

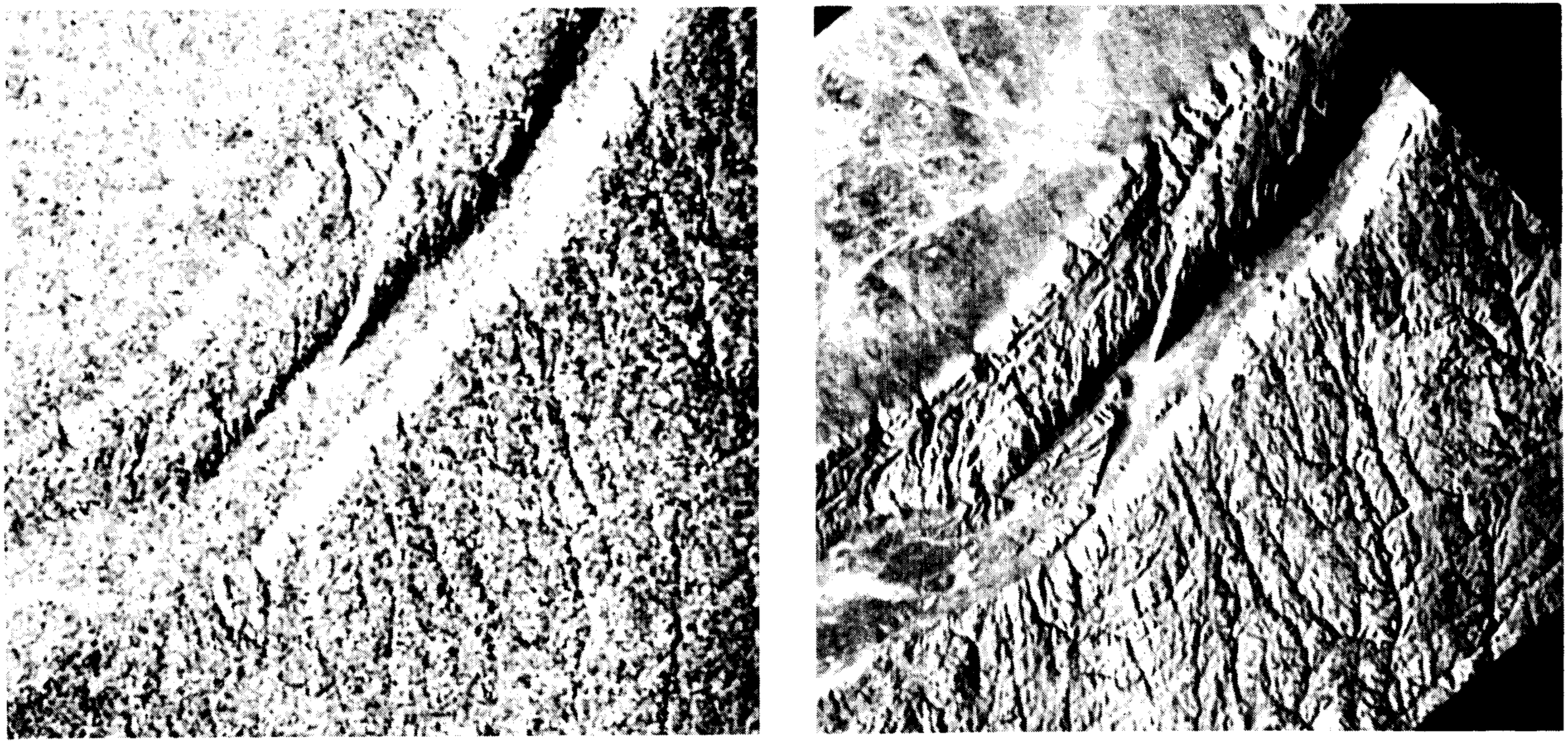

Figure 3. Sierra Ulapes-Sierra Las Minas (31°30'S, 66°30'W). Images by SIR-B (data take 119.5, scene 11) and Landsat (TM 231-82-2) aligned for steroscopic viewing. North to lower left, area about 12.5 x 12.5 km. Radar scene was illuminated toward 041.2°N, look angle 54.4°. By displaying the radar negative, the reversed shading is almost identical to the illumination of the TM scene with sun azimuth 040° and elevation 23°. Resolution is best on the TM scene, but the steroscopic effect is due almost entirely to the oblique look angle of the radar image.